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FURTHER STUDIES WITH PARADICHLOROBENZENE FOR PEACH BORER CONTROL

WITH SPECIAL REFERENCE TO ITS USE ON YOUNG PEACH TREES.

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INTRODUCTION.

The use of paradichlorobenzene for the control of the peach borer (*Aegeria exitiosa* Say) on trees 6 years of age and older has rapidly increased in popularity among peach growers since the appearance of the report by E. B. Blakeslee [1] on his experiments on this new method of control of this most destructive enemy of the peach.

Peach growers throughout the area of distribution of the peach borer east of the Rocky Mountains have already adopted the treatment to a large extent, and in certain important peach-growing areas where the borer is excessively troublesome the employment of paradichlorobenzene has become rather general. Thus in Georgia alone, during 1921, 250,000 pounds of the chemical were used, and possibly more was required during the season of 1922.

The experimental results obtained by Blakeslee showed that this chemical is safe when properly employed for the control of the peach borer on trees 6 years of age and older. In certain cases, however, injury to trees younger than about 6 years occurred. Since the peach borer is often very destructive in young orchards, it is highly desirable, if possible, to use the chemical on trees of all ages. Further experimentation by the Bureau of Entomology and several of the agricultural experiment stations, notably those of New Jersey, Mary-

[1] U. S. Dept. of Agriculture Bulletin 796, Use of Toxic Gases as a Possible Means of Control of the Peach-Tree Borer. 1919.

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land, Indiana, and Illinois, indicates that this can be done, provided the directions for use are carefully followed.

Beginning with the fall of 1921 and extending through the spring of 1922, extensive experiments with paradichlorobenzene were conducted by the Bureau of Entomology in the peach belt of Georgia on trees ranging from 1 to 6 years of age. At the same time studies were made in the laboratory on the effect of temperature and moisture on the rate of evaporation of the chemical, in order to obtain results for comparison with those obtained under orchard conditions.

This bulletin gives a report of progress rather than specific recommendations as to the use of paradichlorobenzene on peach trees younger than 6 years of age. The results obtained are very favorable to the employment of the chemical on young trees. Injury resulted only to a few trees in the way of brown lesions in the outer bark layers. Nevertheless, final recommendations can not be made until additional experimental work is completed. In the meantime peach growers should decide for themselves whether, in view of their individual conditions, they are warranted in adopting the treatment on young trees, or whether they should continue the well-known practice of worming.

EXPERIMENTAL RESULTS IN THE FIELD.

The chief objects of the field experiments were (1) to ascertain what dosages can be used effectively and with safety on young peach trees; (2) to note effects from not opening up soil mounds six weeks after applying the chemical and to note the effects from allowing the crystals to remain around the trees all winter; (3) to determine the effectiveness of late fall, winter, and spring applications to peach trees.

The object of the laboratory work was to determine the effect of temperature and moisture on the rate of evaporation of paradichlorobenzene, and to ascertain what influence these factors have on the mortality of the peach borer from the toxic gas.

FIVE-YEAR-OLD ORCHARD TREES.

One hundred and twenty-two trees were used in an experiment on 5-year-old trees. Both long exposures of small doses and short exposures of large doses were tested. For the long-exposure tests one-half, three-fourths, and 1-ounce doses were applied October 12, 1921. The soil was removed and examinations made on groups of five trees in each test three, four, and six weeks after the material was applied, and on five trees the examination was not made or the soil disturbed until the spring of 1922. Some of the trees in the check or untreated plat of this experiment were examined for borers six weeks after the application was made to the treated trees, and the others the following spring.

For the short-exposure tests, 1½, 2, and 2½ ounce doses were applied October 20, 1921. The soil was removed and examinations made on groups of 5 trees in each test 4, 8, and 12 days later. The trees in the check or untreated plat of this experiment were examined for borers during the latter part of November.

Table 1 gives the results on the effectiveness of the various doses of paradichlorobenzene at different exposures as used on the 5-year-old orchard trees.

TABLE 1.—*Results of different treatments of paradichlorobenzene on peach-borer larvæ in 5-year-old Redbird peach trees, Fort Valley, Ga., 1921–22.*

Number of trees.	Size of dose.	Date applied.	Date examined.	Exposed to gas.	Number of larvæ found.			Per cent of larvæ.		
					Dead.	Stupefied.	Active.	Dead.	Stupefied.	Active.
	Ounces.	1921.	1921–22.	*Days.*						
5	½	Oct. 12	Nov. 3	22	8	2	1	72.7	18.2	9.1
5	½	...do....	9	28	1	0	0	100.0	0	0
5	½	...do....	23	42	3	0	0	100.0	0	0
5	½	...do....	Apr. 13	Over winter.	4	0	0	100.0	0	0
5	¾	...do....	Nov. 3	22	6	1	0	85.7	14.3	0
5	¾	...do....	9	28	17	0	0	100.0	0	0
5	¾	...do....	23	42	5	0	0	100.0	0	0
5	¾	...do....	Apr. 13	Over winter.	1	0	0	100.0	0	0
5	1	...do....	Nov. 3	22	8	0	0	100.0	0	0
5	1	...do....	9	28	19	0	0	100.0	0	0
5	1	...do....	23	42	5	0	0	100.0	0	0
5	1	...do....	Apr. 13	Over winter.	2	0	0	100.0	0	0
5	1½	Oct. 20	Oct. 24	4	2	2	0	50.0	50.0	0
5	1½	...do....	28	8	5	0	1	83.3	0	16.7
5	1½	...do....	Nov. 1	12	16	1	0	94.1	5.9	0
5	2	...do....	Oct. 24	4	4	7	0	36.4	63.6	0
5	2	...do....	28	8	4	0	0	100.0	0	0
5	2	...do....	Nov. 1	12	6	0	0	100.0	0	0
5	2½	...do....	Oct. 24	4	12	7	0	63.2	36.8	0
5	2½	...do....	28	8	8	0	0	100.0	0	0
5	2½	...do....	Nov. 1	12	4	0	0	100.0	0	0
4	Check.	.....	23	.....	0	0	5	0	0	100.0
10	Check.	.....	30	.....	0	0	61	0	0	100.0
3	Check.	.....	Apr. 13	.....	0	0	8	0	0	100.0

FOUR-YEAR-OLD ORCHARD TREES.

In the experiment on 4-year-old trees also, 122 trees were used, and all tests conducted on the 5-year-old trees were duplicated on 4-year-old trees. Table 2 gives the larvicidal action of the various doses at different exposures on 4-year-old trees.

TABLE 2.—*Results of different treatments of paradichlorobenzene on peach-borer larvæ in 4-year-old Redbird peach trees, Marshallville, Ga., 1921–22.*

Number of trees.	Size of dose.	Date applied.	Date examined.	Exposed to gas.	Number of larvæ found.			Per cent of larvæ.		
					Dead.	Stupefied.	Active.	Dead.	Stupefied.	Active.
	Ounces.	1921.	1921–22.	*Days.*						
5	½	Oct. 10	Nov. 1	22	17	0	0	100.0	0	0
5	½	...do.....	7	28	6	0	0	100.0	0	0
5	½	...do.....	21	42	2	0	0	100.0	0	0
5	½	...do.....	Apr. 10	Over winter.	2	0	0	100.0	0	0
5	¾	...do.....	Nov. 1	22	4	0	0	100.0	0	0
5	¾	...do.....	7	28	2	0	0	100.0	0	0
5	¾	...do.....	21	42	0	0	0	.....	.....	.....
5	¾	...do.....	Apr. 10	Over winter.	3	0	0	100.0	0	0
5	1	...do.....	Nov. 1	22	10	5	0	66.7	33.3	0
5	1	...do.....	7	28	0	0	0	.....	.....	.....
5	1	...do.....	21	42	3	0	0	100.0	0	0
5	1	...do.....	Apr. 10	Over winter.	4	0	0	100.0	0	0
5	1½	Oct. 17	Oct. 21	4	3	2	0	60.0	40.0	0
5	1½	...do.....	25	8	6	0	0	100.0	0	0
5	1½	...do.....	29	12	9	5	0	64.3	35.7	0
5	2	...do.....	21	4	16	5	0	76.2	23.8	0
5	2	...do.....	25	8	4	1	0	80.0	20.0	0
5	2	...do.....	29	12	13	2	0	86.7	13.3	0
5	2½	...do.....	21	4	6	7	0	46.2	53.8	0
5	2½	...do.....	25	8	0	0	0	.....	.....	.....
5	2½	...do.....	29	12	1	0	0	100.0	0	0
9	Check.	.....	Nov. 21	.....	0	0	32	0	0	100.0
5	Check.	.....	27	.....	0	0	11	0	0	100.0
3	Check.	.....	Apr. 10	.....	0	0	16	0	0	100.0

THREE-YEAR-OLD ORCHARD TREES.

The same experiments conducted on the 5-year-old and 4-year-old trees were also conducted on 3-year-old trees. Table 3 gives the results on effectiveness of the various doses used.

TABLE 3.—*Results of different treatments of paradichlorobenzene on peach-borer larvæ in 3-year-old Hale peach trees, Fort Valley, Ga., 1921–22.*

Number of trees.	Size of dose.	Date applied.	Date examined.	Exposed to gas.	Number of larvæ found.			Per cent of larvæ.		
					Dead.	Stupefied.	Active.	Dead.	Stupefied.	Active.
	Ounces.	1921.	1921–22.	*Days.*						
5	¼	Oct. 11	Nov. 2	22	0	0	1	0	0	100.0
5	¼	...do.....	8	28	0	0	1	0	0	100.0
5	¼	...do.....	22	42	0	0	0	.....	.....	.....
5	¼	...do.....	Apr. 12	Over winter.	0	0	0	.....	.....	.....
5	¾	...do.....	Nov. 2	22	0	0	0	.....	.....	.....
5	¾	...do.....	8	28	0	0	0	.....	.....	.....
5	¾	...do.....	22	42	0	0	0	.....	.....	.....
5	¾	...do.....	Apr. 12	Over winter.	2	0	0	100.0	0	0
5	1	...do.....	Nov. 2	22	0	0	0	.....	.....	.....
5	1	...do.....	8	28	0	0	0	.....	.....	.....
5	1	...do.....	22	42	0	0	0	.....	.....	.....
5	1	...do.....	Apr. 12	Over winter.	0	0	0	.....	.....	.....
5	1½	Oct. 18	Oct. 22	4	0	0	0	.....	.....	.....
5	1½	...do.....	26	8	0	0	0	.....	.....	.....
5	1½	...do.....	31	13	0	0	0	.....	.....	.....
5	2	...do.....	22	4	2	1	0	66.7	33.3	0
5	2	...do.....	26	8	1	0	0	100.0	0	0
5	2	...do.....	31	13	0	0	0	.....	.....	.....
5	2½	...do.....	22	4	0	0	0	.....	.....	.....
5	2½	...do.....	26	8	0	0	0	.....	.....	.....
5	2½	...do.....	31	13	0	0	0	.....	.....	.....
14	Check.	.....	Nov. 22	.....	0	0	2	0	0	100.0
3	Check.	.....	Apr. 12	.....	0	0	0	.....	.....	.....

TWO-YEAR-OLD ORCHARD TREES.

In the experiment on 2-year-old trees 105 trees were used. The tests included both long exposures of small doses and short exposures of large doses. For the long-exposure tests, one-half and three-fourths ounce doses were applied October 11, 1921. The soil was removed and examinations made on groups of five trees in both the one-half and three-fourths ounce test plats three, four, and six weeks after the material was applied. The check or untreated plat of this experiment was examined six weeks after the application was made to the treated trees.

For the short-exposure tests, three-fourths, 1, 1½, and 2 ounce doses were applied October 21, 1921. The soil was removed and examinations made on groups of five trees in each test 4, 8, and 12 days later. The trees in the check or untreated plat of this experiment were examined for borers the latter part of November.

Table 4 gives the results on effectiveness of the various doses used on the 2-year-old trees.

TABLE 4.—*Results of different treatments of paradichlorobenzene on peach-borer larvæ in 2-year-old Hiley peach trees, Winchester, Ga., 1921–22.*

Number of trees.	Size of dose.	Date applied.	Date examined.	Exposed to gas.	Number of larvæ found.			Per cent of larvæ.		
					Dead.	Stupefied.	Active.	Dead.	Stupefied.	Active.
	Ounces.	1921.	1921–22.	*Days.*						
5	¼	Oct. 11	Nov. 2	22	0	0	0	.....	.....	.....
5	¼	...do.....	8	28	0	0	0	.....	.....	.....
5	¼	...do.....	22	42	0	0	0	.....	.....	.....
5	¼	...do.....	2	22	0	0	0	.....	.....	.....
5	¼	...do.....	8	28	0	0	0	.....	.....	.....
5	¼	...do.....	22	42	0	0	0	.....	.....	.....
5	¾	Oct. 21	Oct. 25	4	1	0	0	100.0	0	0
5	¾	...do.....	29	8	1	0	0	100.0	0	0
5	¾	...do.....	Nov. 2	12	0	0	0	.....	.....	.....
5	1	...do.....	Oct. 25	4	0	4	0	0	100.0	0
5	1	...do.....	29	8	1	0	0	100.0	0	0
5	1	...do.....	Nov. 2	12	0	0	0	.....	.....	.....
5	1½	...do.....	Oct. 25	4	0	0	0	.....	.....	.....
5	1½	...do.....	29	8	0	0	0	.....	.....	.....
5	1½	...do.....	Nov. 2	12	0	0	0	.....	.....	.....
5	2	...do.....	Oct. 25	4	0	0	0	.....	.....	.....
5	2	...do.....	29	8	0	0	0	.....	.....	.....
5	2	...do.....	Nov. 2	12	0	0	0	.....	.....	.....
15	Check.	.....	22	.....	0	0	0	.....	.....	.....

ONE-YEAR-OLD ORCHARD TREES.

On account of the possibility of severe tree injury resulting from the use of paradichlorobenzene on 1-year-old trees, only a few trees were used in this experiment. One-half and three-fourths ounce doses were applied on October 11, 1921, and the trees were exposed to the treatment for 22 days. One-ounce doses were applied on October 21, 1921, and the trees exposed for 18 days. Table 5 gives the larvicidal action of the various doses used.

TABLE 5.—*Results of different treatments of paradichlorobenzene on peach-borer larvæ in 1-year-old Hiley peach trees, Winchester, Ga., 1921–22.*

Number of trees.	Size of dose.	Date applied.	Date examined.	Exposed to gas.	Number of larvæ found.			Per cent of larvæ.		
					Dead.	Stupefied.	Active.	Dead.	Stupefied.	Active.
	Ounce.	1921.	1921.	*Days.*						
4	¼	Oct. 11	Nov. 2	22	2	0	0	100.0	0	0
4	¼	11	2	22	0	0	0	.....	.....	.....
4	1	21	8	18	0	0	0	.....	.....	.....

SUMMARY OF RESULTS.

Table 6 brings together the results from all treatments on peach trees ranging in age from 1 to 5 years.

TABLE 6.—*Summary of results of different treatments of paradichlorobenzene on peach-borer larvæ in 1 to 5-year-old peach trees, central Georgia, 1921–22.*

Days larvæ were exposed to gas (1921).	½-ounce dose.					¾-ounce dose.					1-ounce dose.				
	Trees.	Larvæ.			Per cent killed.	Trees.	Larvæ.			Per cent killed.	Trees.	Larvæ.			Per cent killed.
		Dead.	Stupefied.	Active.			Dead.	Stupefied.	Active.			Dead.	Stupefied.	Active.	
4 days	....	....	....	....	.....	5	1	0	0	100	5	0	4	0	.....
8 days	....	....	....	....	.....	5	1	0	0	100	5	1	0	0	100
12 days	....	....	....	....	.....	5	0	0	0	.....	5	0	0	0	.....
22 days	24	27	2	2	87.1	24	10	1	0	90.9	15	18	5	0	78.3
28 days	20	7	0	1	87.5	20	19	0	0	100	15	19	0	0	100
42 days	20	5	0	0	100	20	5	0	0	100	15	8	0	0	100
Over winter	15	6	0	0	100	15	6	0	0	100	15	6	0	0	100
Check	....	....	....	....	.....	....	....	....	....	.....	....	....	....	....	.....

Days larvæ were exposed to gas (1921).	1½-ounce dose.					2-ounce dose.					2½-ounce dose.					Check.		
	Trees.	Larvæ.			Per cent killed.	Trees.	Larvæ.			Per cent killed.	Trees.	Larvæ.			Per cent killed.	Trees.	Larvæ.	
		Dead.	Stupefied.	Active.			Dead.	Stupefied.	Active.			Dead.	Stupefied.	Active.			Dead.	Active.
4 days	20	5	4	0	55.6	20	22	13	0	62.9	15	18	14	0	56.3	....	....	....
8 days	20	11	0	1	91.7	20	9	1	0	90.0	15	8	0	0	100	....	....	....
12 days	20	25	6	0	80.7	20	19	2	0	90.5	15	5	0	0	100	....	....	....
22 days	....	....	....	....	.....	....	....	....	....	.....	....	....	....	....	.....	....	....	....
28 days	....	....	....	....	.....	....	....	....	....	.....	....	....	....	....	.....	....	....	....
42 days	....	....	....	....	.....	....	....	....	....	.....	....	....	....	....	.....	....	....	....
Over winter	....	....	....	....	.....	....	....	....	....	.....	....	....	....	....	.....	....	....	....
Check	....	....	....	....	.....	....	....	....	....	.....	....	....	....	....	.....	66	0	135

In making examinations for results many very small larvæ that were killed by the gas could not be located. This is proved by the infestation of the check trees, which contained an average of over 2 borers per tree as compared with an average of less than 1 borer per tree located in the treated trees when making the examinations.

The results of these experiments show that the large doses exposed for 4, 8, or 12 days are not as effective as the smaller doses exposed for 4 to 6 weeks. While the percentage of kill was high from some of the short exposures, yet others were so low in percentage of kill that the short-exposure treatments as a whole could not be considered effective. Both the three-fourths and 1 ounce doses exposed for 28 days or longer gave 100 per cent control.

EFFECT OF PARADICHLOROBENZENE ON THE TREES.

Three separate examinations for tree injury from the various paradichlorobenzene treatments were made on all trees from 1 to 5 years of age. The first of these examinations was made in the fall of 1921, about six weeks after the material was applied. The second examination was made during the spring of 1922, and the third and final examination was made in July, 1922. The condition of the tree and trunk at the final examination is given in the following summary from the field notes:

ONE-YEAR-OLD TREES.

Eight 1-year-old Hiley peach trees exposed 12 days with one-half and three-fourths ounce doses showed no injury to either the trees or trunks. Of four 1-year-old Hiley trees exposed 18 days to 1-ounce doses two of the trunks showed some injury which might be attributed to the paradichlorobenzene. The trunk of one of these trees showed severe peppering with small brown lesions in the outer bark layers at about the place where the crystal ring had been placed. The cambium was uninjured. The other injured tree showed only slight peppering of the outer bark layers with small brown lesions. Both of these trees appeared very healthy from the top, and had apparently not been affected by the paradichlorobenzene dose.

TWO-YEAR-OLD TREES.

Of thirty 2-year Hiley peach trees exposed to one-half and three-fourths ounce doses from three to six weeks, all appeared very healthy and vigorous from the top when the final examinations for tree injury were made. (Pl. I.) The trunks also showed no injury whatever, with the exception of four. These four showed a slightly peppered appearance in the outer bark layers, but the cambium was uninjured. Of sixty 2-year-old trees treated with doses varying from three-fourths to 2 ounces exposed to the gas from 4 to 12 days, all were very healthy and growing vigorously. The trunks of 58 were uninjured, while 2 showed the outer bark layers slightly peppered with brown lesions. The 15 check or untreated trees were all healthy and vigorous when each examination was made. The trunks showed no abnormal condition of the outer bark layers or cambium.

THREE-YEAR-OLD TREES.

Sixty 3-year-old Hale peach trees treated with doses varying from one-half to 1 ounce showed no injury from the paradichlorobenzene to either the trunk or the tree at any of the three examinations. The mounds around 15 of these trees were not disturbed after the paradichlorobenzene was applied until the spring of 1922. The other 45 trees were exposed to the gas for periods varying from three to six weeks. Forty-five other 3-year-old trees treated with 1½ to 2½ ounce doses and exposed from 4 to 12 days showed no injury to the trunk or tree at any of the examinations. The 17 trees used as checks in this experiment appeared the same as the treated trees when each examination was made. The 3-year-old trees used for this experiment were exceedingly healthy and vigorous, and the bark layers were thick for trees of that age.

FOUR-YEAR-OLD TREES.

The trees used for the four-year experiment were of the Redbird variety, and the orchard as a whole was in very poor condition and the trees neglected. Sixty of these trees were treated with doses varying from one-half to 1 ounce and 45 were exposed to the gas for periods ranging from three to six weeks. The mounds around the remaining 15 were not disturbed until the spring of 1922. At the final examination 16 of the 60 trees showed peppering with brown lesions on the trunk at about the place where the paradichlorobenzene

ring had come in close proximity to the bark. The trunks of the other trees did not show any injurious effects from the use of the chemical. A detailed study of the bark of some of the injured trees showed brown flecks in the 1920 and 1921 layers, and two flecks had merged into the 1922 layer. The layers inside and outside of the 1920 and 1921 layers were practically free from flecks. The injury occurred over a distance of about 1 inch at the point where the crystals had been placed around the tree. There was no injury above or below this point. The gas passed through from 2 to 4 millimeters of outer bark layers without causing any visible injury. In the next 2 millimeters of bark, which includes the 1920 and 1921 bark layers, brown flecks from ½ to 1 millimeter in diameter, somewhat ellipsoidal, the long axis parallel with the bark rays, extended to within 1 millimeter of the cambium at the time of treatment. The largest flecks were about 3 millimeters long and 1 millimeter wide and about 10 flecks may occur per centimeter of circumference of the tree.

Of forty-five 4-year-old trees treated with doses varying from 1½ to 2½ ounces and exposed to the gas from 4 to 12 days, 44 were healthy and showed no injury to the trunk. One showed some peppering. The 17 untreated trees were all healthy.

On account of improper handling and neglect in the 4-year-old orchard, the trees had made very poor growth. Measurements of the trees used for paradichlorobenzene experiments in this orchard averaged 1 foot 1 inch in circumference, and 9 feet 2 inches in height. The measurements of the trees used in the 3-year-old orchard averaged 1 foot 2½ inches in circumference and 10 feet 5 inches in height. The difference in size and vitality perhaps influenced injury on the 4-year-old trees, where the bark layers were perhaps even thinner than the layers on the vigorous 3-year-old trees, which showed no indications whatever of injury from the use of paradichlorobenzene.

FIVE-YEAR-OLD TREES.

Sixty 5-year-old Redbird peach trees were treated with doses varying from one-half to 1 ounce, 45 of which were exposed to the gas for periods ranging from 3 to 6 weeks, while the mounds around the remaining 15 were allowed to remain around the trees throughout the winter. At each examination made for tree injury no injurious effects from the use of the paradichlorobenzene to the trunk or tree in the case of these trees were observed. Forty-five trees were exposed to 1½ to 2½ ounce doses for from 4 to 12 days with no injury to either the trunk or the tree. The check or untreated trees were in the same condition as the treated ones, and in no case among all the 5-year-old trees used for the experiment could any injury to the tree or trunk be attributed to paradichlorobenzene.

SIX-YEAR-OLD TREES.

Forty 6-year-old Redbird peach trees were treated with 1-ounce doses late in the fall of 1921, and the mounds left up around the trees over winter. Examinations made in the spring and again in July of 1922 showed no tree or trunk injury from the late use of the chemical on trees of this age and from allowing the mounds to remain around the trees over winter. Twenty-four trees treated in the spring of 1922 with 1-ounce doses showed no injury from paradichlorobenzene

CONDITION OF 2-YEAR-OLD HILEY PEACH ORCHARD IN THE SPRING AFTER BEING PARTIALLY TREATED WITH PARADICHLOROBENZENE THE PRECEDING FALL.

1. First four rows treated, others untreated. 2. Rows to left treated, those to right untreated.

when examinations for tree injury were made in July of the same year. In no case among all the 6-year-old trees treated in late fall or in the spring could any injury to the cambium layer be attributed to the paradichlorobenzene treatment.

DISCUSSION.

The characteristic severe tree injury from the use of paradichlorobenzene on young peach trees reported as a result of experimental work conducted in more northern latitudes did not occur on any of the young trees used for the experimental work in Georgia during 1921–22. Different climatic conditions which usually cause rapid evaporation of the crystals may be responsible, and these are such that perhaps it may be possible to use this new treatment on young peach trees in Georgia and other Southern States without injury to the tree. During a normal fall in central Georgia a 1-ounce dose placed around a peach tree will entirely evaporate and leave no traces of odor within six weeks.

In no case among the 558 young peach trees used in the paradichlorobenzene experimental work in Georgia during 1921–22 could it be determined that the cambium layer was injured as a result of the toxic action of the gas; but in some instances, previously noted, brown lesions were observed in the outer bark layers that could be attributed to the gas, since most of the lesions were at a point on the trunk near which the crystal ring had been placed. No special injury from leaving the mounds around the trees all winter after making the application could be discerned.

Notes were kept on the quantity of crystals left and the odor present when each tree base was opened for examination. These notes revealed the fact that in the majority of cases 1-ounce doses will entirely evaporate and the odor disappear within six weeks during a normal October and November in the latitude of Georgia, provided too much earth is not placed over the crystals in mounding after applying the chemical. Hence during a normal fall it is not necessary to uncover the base of the trees, especially the old ones, in Georgia and the Gulf States six weeks after applying the chemical in order to allow the gas to escape, or to remove any remaining crystals. If the fall is cool or if the material has been applied very late, this additional precaution against injury might be considered and the tree bases uncovered six weeks after applying the material. This precaution might also be taken if the material is used on young trees.

Since the three-fourths and 1-ounce doses exposed for four weeks or longer resulted in a better control of the peach borer than the large doses with short exposures, and since the effect on the trees from these long exposures was no greater than from the large doses with short exposures, it is suggested that in using paradichlorobenzene on peach trees 4 years old or younger in Georgia the three-fourths ounce dose be used and allowed to remain around the trees for four weeks. As an added precaution against injury on young trees, uncover the base of the tree four weeks after applying the chemical. On peach trees 5 years old and older in Georgia, use the full 1-ounce dose, and if the chemical is applied at the time recommended and if the fall is not abnormally cold it will not be necessary to uncover the base of the old trees after applying the paradichlorobenzene.

RESULTS FROM WINTER AND SPRING TREATMENTS.

To obtain information on the results that may be expected to follow the application of paradichlorobenzine to peach trees in the late fall or spring for the control of the peach borer, an experiment was conducted on 6-year-old trees during the fall of 1921 and the spring of 1922. This experiment also furnished additional data on the results from not uncovering the tree base after applying the chemical.

Eighty trees were used in this experiment and 1-ounce doses were applied in all tests. Ten of the trees were treated October 24, which was about two weeks after the usual time. These trees were not examined or the soil disturbed until May 5, 1922. Ten other trees were treated on November 9, which was about four weeks later than the time for best results. Ten others were treated on November 23, which was about six weeks late, and 10 others on December 6, which was eight weeks later than the date recommended for best results. None of these trees was examined nor was the soil around them disturbed until May 5, 1922. Ten untreated trees were examined on May 6, as a check on this experiment.

For the spring test 1-ounce doses were applied April 3, 1922, to twenty-five 6-year-old trees which had not been treated the previous fall. By this date the daily soil temperature in Georgia was averaging over 60° F. at a depth of 3 inches. These trees were all examined on May 13, 1922, or about six weeks after the material was applied. Five untreated trees used as a check on this experiment were also examined on May 13.

Table 7 gives the summary of results on the effect of late fall and spring treatments of 1-ounce doses of paradichlorobenzene on peach-borer larvæ.

TABLE 7.—*Summary of results of late fall and spring 1-ounce dose treatments of paradichlorobenzene on peach-borer larvæ in 6-year-old Redbird peach trees, Fort Valley, Ga., 1921–22.*

Number of trees.	Date applied.	Date examined.	Exposed to gas.	Number and condition of larvæ.									Per cent larvæ.		
				Dead.			Stupefied.			Active.					
				One-half grown.	Three-fourths grown.	Over three-fourths grown.	One-half grown.	Three-fourths grown.	Over three-fourths grown.	One-half grown.	Three-fourths grown.	Over three-fourths grown.	Dead.	Stupefied.	Active.
	1921–22.	1922.													
10	Oct. 24	May 5	Over winter (193 days).	1	2	....	....	....	....	....	1	....	75.0	0	25.0
10	Nov. 9	...do.....	Over winter (177 days).	....	....	2	....	....	....	....	....	....	100.0	0	0
10	Nov. 23	...do.....	Over winter (163 days).	1	2	....	....	....	....	....	....	....	100.0	0	0
10	Dec. 6	...do.....	Over winter (150 days).	....	....	....	....	....	....	....	1	2	0	0	100.0
10	Check...	May 6	.....	....	....	....	....	....	....	17	31	15	0	0	100.0
25	Apr. 3	May 13	40 days.....	7	10	4	2	1	0	0	4	1	72.4	10.4	17.2
5	Check...	...do.....	.....	....	....	....	....	....	....	1	....	8	0	0	100.0

It is difficult to locate dead borers 150 to 200 days after applying the chemical, on account of decomposition; hence the few borers recorded on long exposures above. The checks show the number probably present when the experiment began.

Table 7 shows that the spring treatment of paradichlorobenzene in Georgia is not as effective for the control of the peach borer as the early fall treatment. This is perhaps largely due to the size of the larvæ in the spring and the fact that many individuals are in deep galleries by that time. The larger the borers and the deeper they are in the gallery the more difficult it is to kill them with paradichlorobenzene gas. The 1922 spring treatment gave a borer mortality of 72.4 per cent. The early fall treatment gave from 95 to 100 per cent

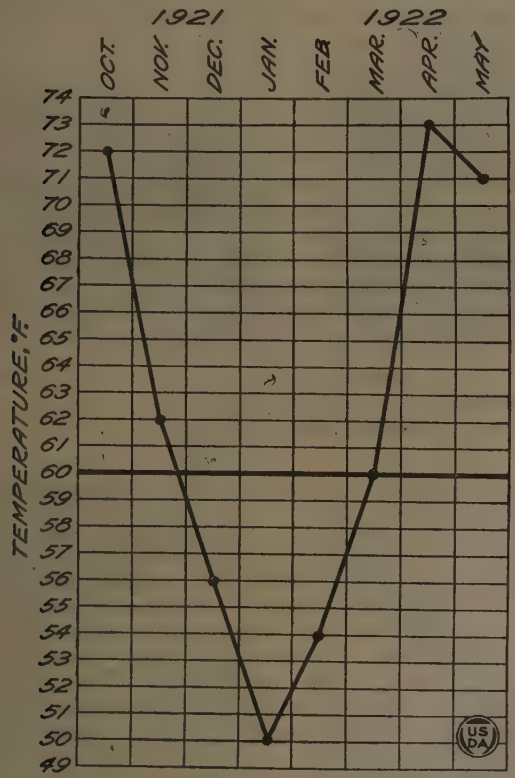

FIG. 1.—Monthly mean soil temperature 3 inches below the surface, at Fort Valley, Ga. (The heavy horizontal line indicates the lowest temperature for best results with paradichlorobenzene.)

mortality; 17.2 per cent of the borers were active six weeks after the spring applications were made, and 10.4 per cent of them were stupefied.

Spring applications of paradichlorobenzene will not give as satisfactory control of the peach borer as the early fall applications, and they can not take the place of the fall treatments. They should only be used where for an unavoidable reason the grower was not able to apply the material in the fall. Where conditions warrant these spring applications, they should be applied by April 1 in Georgia and the Gulf States. For best results with paradichlorobenzene, it

must be placed around the trees when the soil temperature is 60° F. or higher. Figure 1 shows that the soil does not warm up sufficiently for applications before April 1. On the other hand it is important to prevent tree damage from the borers as soon as possible and to kill them before they have gone deep in their galleries or have attained large size. Consequently, do not wait later than April 1 for spring applications.

The results from the application made on December 6 were very poor. When the examinations on these trees were made on May 5 every borer that could be located was active. Of course, some may have been killed and decomposed before the examinations were made. The poor results can be attributed to the fact that the soil is too cold during December in Georgia for the generation of gas from paradichlorobenzene crystals. As shown in Figure 1, the average soil temperature during December, 1921, was 56° F. Some of the applications made at two-week intervals after October 15 gave very good results, yet 25 per cent of the borers were active in the spring in trees that had been treated with paradichlorobenzene October 24, or two weeks later than the usual time.

For best results, paradichlorobenzene must be applied in the early fall, at the close of the oviposition period of the adult. At this time the borers are small and the galleries are shallow. Furthermore, 1-ounce doses applied immediately after the oviposition season will evaporate entirely in six weeks, or before the soil temperature becomes too low for the gas to generate. The work reported here shows that the best results with paradichlorobenzene for peach-borer control in central Georgia will be obtained by placing the crystals around the trees October 10.

CORRECT METHOD OF APPLYING PARADICHLOROBENZENE.

In practically every case where a peach grower failed to get satisfactory control of the peach borer with paradichlorobenzene it was found that the directions for applying the chemical were not closely followed. It is absolutely essential to follow the directions very closely if best results are to be obtained with paradichlorobenzene.

It must be remembered that the gas given off from paradichlorobenzene crystals is much heavier than air, and borers in a tree above the point where the crystals are placed will not be affected by the gas. Consequently, the first thing to do in treating a tree is to determine the topmost borer gallery. Usually this will not be above the soil level, and, in such case, the soil should not be mounded or disturbed before applying the paradichlorobenzene, except to remove weeds, stones, etc., and to make the soil surface level, using the back of a shovel. If gum, sawdust, or frass is thrown out from the tree trunk above the soil level, one can be reasonably sure that some borers are working in the tree above the soil. In these cases mound up the tree with earth, so that the ring of crystals can be placed above the topmost borer gallery. This is necessary in order that the gas may reach the borers above the soil level. Do not mound trees before applying the chemical, however, unless there are distinct indications of borer work above ground.

The dose of paradichlorobenzene is then applied in a continuous band about 2 inches wide and about 1 inch from the tree trunk. Care

THE PROPER WAY TO USE PARADICHLOROBENZENE.

1. The soil around the tree is made ready for treatment. 2. The paradichlorobenzene is applied in a continuous ring 2 inches wide and 1 inch from the tree trunk. This is the correct method. 3. Several shovelfuls of soil are placed on the crystals and compacted, to hold the gas and prevent surface washing. 4. In the case of young trees, the base is uncovered four weeks after the paradichlorobenzene is applied.

IMPROPER WAYS OF APPLYING PARADICHLOROBENZENE.

1. The crystal ring is too close to the tree trunk. It should be at least 1 inch away. 2. The crystal ring is too far from the tree trunk for good results. 3. The soil level should have been raised around this tree before applying the crystals, as there are borers at work above the present soil level. No borers will be killed above the crystal ring, as the gas is heavier than air.

should be used to distribute the crystals as evenly as possible, as the action of the gas is local. Use only pure paradichlorobenzene having a fineness of granulated sugar. One-ounce doses should be used on trees 5 years old and older, and if this material is used on younger trees the three-fourths ounce dose is suggested. After the crystals are placed around the tree, cover them with several shovelfuls of soil and compact with a sharp blow or two, using the back of the shovel. This produces a slight mound which prevents the crystals from washing and also serves as a container for the gas. Avoid pushing the crystals against the tree trunk with the first shovelful of soil. If paradichlorobenzene is used on trees younger than 5 years old, the mounds should be opened four weeks later to remove any unspent crystals or to allow any remaining gas to escape. In the latitude of central Georgia it will not be necessary to open the mounds after treating trees 5 years old or older. Plates II and III show proper and improper methods of applying paradichlorobenzene.

For best results the chemical must be applied in the peach belt of central Georgia from October 10 to 15. In northern Georgia the material should be applied about October 1, and in southern Georgia, October 15 to 20. The same dates should be applicable for similar latitudes in the other Gulf States.

LABORATORY EXPERIMENTS.

In connection with the field work on paradichlorobenzene, several tests were made with the material in the laboratory. Field conditions were somewhat different from those in the laboratory, but the two were made as nearly similar as possible. The evaporation of the gas in the laboratory was slower than in the field, as in the latter case the material was subjected to a higher temperature due to its being exposed to the direct rays of the sun. In testing the killing effect of paradichlorobenzene on peach-borer larvæ, the gas was concentrated in a small area and the action was somewhat faster than under normal field conditions.

RATE OF EVAPORATION OF PARADICHLOROBENZENE CRYSTALS.

The paradichlorobenzene crystals used to determine the rate of evaporation were about as fine as granulated sugar. The soils used were red clay and sandy loam. One-half ounce of paradichlorobenzene was used in all tests and was imbedded from 4 to 6 inches in the soil, with the exception of one test, where the crystals were placed on the surface of the soil. Some of the soils were used just as they came from the field; others had various amounts of water added up to the point of saturation.

In the sandy loam soils the crystals evaporated at about the same rate, whether 4 or 6 inches below the surface. The evaporation was somewhat faster in red clay when the crystals were only 4 inches down in the soil. The evaporation in the cages to which water had been added was retarded at first, but in about two weeks it was about the same as in normal [2] soils. It took from 91 to 135 days for all of the paradichlorobenzene to disappear, with the exception of the single cage in which the material was placed on the surface. The

[2] The soil used as it came from the orchard without the addition of water is henceforth designated in this paper as normal soil

crystals disappeared in this cage in 16 days. The two types of soil showed very little difference in the rate of evaporation. It would appear that moisture in the soil in central Georgia soon evaporates and does not decrease the efficiency of the gas to any extent unless continuous rainy weather occurs during the period of the generation of the gas. Table 8 gives a summary of the results obtained on the rate of evaporation of the crystals.

TABLE 8.—*Rate of evaporation of paradichlorobenzene crystals in the laboratory, Fort Valley, Ga., 1921–22.*

One-half ounce dose to all cages on Oct. 13, 1921; one-half ounce=219 grains.]

Depth of crystals in the soil.	Amount of moisture added Oct. 13.	Soil type.	Amount of evaporation, in grains (losses between succeeding dates).										Date total amount evaporated.	Number of days required to evaporate crystals.
			1921						1922					
			Oct. 13.	Oct. 26.	Nov. 3.	Nov. 16.	Dec. 1.	Dec. 15.	Jan. 5.	Jan. 12.	Feb. 4.	Feb. 18.	Feb. 25.	
Surface	Normal soil	Sandy loam.	122	83	....	....	....	....	....	....	....	....	....	Oct. 30	16
4 inches	do	do	17	18	8	45	47	19	....	48	....	17	....	Feb. 18	128
6 inches	do	do	16	5	10	31	58	27	....	37	....	35	....	do	128
4 inches	180 cubic centimeters of water added.[a]	do	7	18	4	52	52	39	....	39	8	....	....	Feb. 4	114
6 inches	do.[a]	do	8	12	12	28	59	39	....	38	23	....	....	do	114
4 inches	Saturated[a]	do	0	3	18	64	61	30	....	43	....	....	....	Jan. 12	91
6 inches	do.[a]	do	0	13	22	66	44	51	23	....	....	....	....	Jan. 5	84
4 inches	Normal soil	Red clay	10	15	13	63	49	35	....	34	....	....	....	Jan. 12	91
6 inches	do	do	8	7	10	39	49	42	....	42	....	22	....	Feb. 18	128
4 inches	180 cubic centimeters of water added.	do	0	19	21	41	53	43	....	42	....	....	....	Jan. 12	91
6 inches	do.[a]	do	0	14	14	38	39	33	....	36	....	35	10	Feb. 25	135
4 inches	Saturated[a]	do	0	27	24	62	38	41	27	....	....	....	....	Jan. 5	84
6 inches	do.[a]	do	0	18	21	42	58	45	....	35	....	....	....	Jan. 12	91

[a] This water added to soil in flowerpots 10 inches high and 6 inches wide. These pots were used as soil containers for all of the above paradichlorobenzene evaporation tests.

MORTALITY OF PEACH-BORER LARVÆ EXPOSED TO PARADICHLOROBENZENE.

Peach-borer larvæ were collected in the field and brought to the insectary to determine the effect of paradichlorobenzene on them. All larvæ were placed on peach bark and set in the soil from 3 to 12 inches below the crystals. From one-half ounce to 2 ounces of paradichlorobenzene was used in the different cages that contained the larvæ. Each cage had five larvæ, and all were killed in three weeks' time. The larvæ that were placed in normal soil with from one-half ounce to 2 ounces of paradichlorobenzene per cage were all killed within two weeks. The generation of gas was retarded somewhat in the cages where a large amount of moisture had been added, but the larvæ in these cages did not live more than a week longer than those placed in normal soil. One cage had no crystals in it, and all the larvæ in this cage were alive and feeding at the close of the experiment. The standard 1-ounce doses killed all larvæ in two weeks, although the larvæ did a little feeding before death. The odor of gas was noticeable in one week at the bottom of all cages except those to which 360 and 540 cubic centimeters of water had been added, in which it did not become strong until the end of the second week. Table 9 summarizes the results obtained and shows that the paradichlorobenzene is effective in killing the larvæ as far down as 1 foot, under normal conditions and standard dosage.

TABLE 9.—*Mortality of peach-borer larvæ exposed to paradichlorobenzene in cages at insectary, Fort Valley, Ga., 1921.*

[All larvæ exposed to the gas October 19, 1921. Sandy loam used in all cages.]

Dose.	Number of larvæ.	Depth in soil.	Condition of soil.	Condition of larvæ.									Remarks.
				Oct. 26.			Nov. 3.			Nov. 10.			
				Dead.	Stupefied.	Active.	Dead.	Stupefied.	Active.	Dead.	Stupefied.	Active.	
Ounces.		*Inches.*											
½	5	3	Normal	5	0	0							Odor and crystal at close.
½	5	6	do	4	1	0	0	1	0	1	0	0	Few crystals Nov. 10.
¾	5	3	do	4	1	0	1	0	0				Many crystals left Nov. 10.
¾	5	6	do	5	0	0							Crystals left at close of cage.
1	5	3	do	4	1	0	1	0	0				1 larva fed before death.
1	5	6	do	4	1	0	1	0	0				2 larvæ fed before death.
1	5	12	do	3	2	0	2	0	0				2 larvæ fed before death; many crystals left at close.
1½	5	3	do	5	0	0							5 dead at 1 week's exposure; over 1 ounce paradichlorobenzene left Oct. 26.
1½	5	6	do	4	1	0							4 dead at 1 week's exposure; over 1½ ounces paradichlorobenzene left Oct. 26.
1½	5	12	do	3	2	0							3 dead at 1 week's exposure; over 1½ ounces paradichlorobenzene left Oct. 26.
2	5	6	do	4	1	0							4 dead at 1 week's exposure; over 1½ ounces paradichlorobenzene left Oct. 26.
1	5	6	180 cubic centimeters of water added.	5	0	0							Larvæ fed before death.
1	5	6	360 cubic centimeters of water added.	1	4	0	2	2	0	1	1	0	Larvæ fed before death; no odor at bottom of cage Oct. 26; last larva died Nov. 17.
1	5	6	540 cubic centimeters of water added.	1	0	4	3	1	0	1	0	0	Larvæ fed before death; no odor at bottom of cage Oct. 26.
Check.	5	3	Normal	0	0	5	0	[1]1	4	0	0	5	1 larva away from food Nov. 3.

[1] Sluggish.

NOTE.—All larvæ confined in flowerpots or battery jars 10 inches high and 6 inches wide, except several that were in cages 12 inches tall. Odor stronger than around treated trees in the field.

EFFECT OF TEMPERATURE AND MOISTURE ON THE EFFECTIVENESS OF PARADICHLOROBENZENE.

In determining the killing effect of paradichlorobenzene on peach-borer larvæ, with different degrees of temperature and different amounts of moisture, the standard 1-ounce dose was used throughout the experiment. In November and December, 1921, at a maximum temperature of 69° F. and with the moisture in the soil ranging from 9.15 per cent (normal soil) to 20.15 per cent, all larvæ were killed in 13 days. At 64° F. maximum, and 1.24 per cent moisture (normal soil), 5 larvæ were killed in 7 days. At 64° F. maximum, with from 8.34 per cent to 11.44 per cent moisture, all larvæ were killed in 15 days. In the cage with no paradichlorobenzene, 4 larvæ remained alive and fed continuously throughout the experiment, and one died, probably from lack of food. Table 10 gives a summary of the results obtained.

TABLE 10.—*Effect of temperature and moisture on larvicidal action of paradichlorobenzene, and time required to cause death, 1921.*

Cage No.	Maximum temperature during exposure.	Per cent of moisture in soil when larvæ were exposed to gas.	Date larvæ were exposed to gas.	Condition of larvæ.						Days required to kill larvæ.	Per cent killed.	Remarks.
				Nov. 10.			Nov. 17.					
				Dead.	Stupefied.	Active.	Dead.	Stupefied.	Active.			
	° F.	Per cent.	1921.								Per ct.	
I	69	16.75	Nov. 4	3	2	0	2	0	0	5 killed in 13 days.	100	Average temperature 59.9° F.; larvæ did no feeding.
II	69	20.15	...do.....	3	1	1	2	0	0	...do.....	100	Average temperature 59.9° F.; larvæ fed a little.
III	69	[1] 9.15	...do.....	1	4	0	4	0	0	...do.....	100	Average temperature 60.1° F.; larvæ did no feeding.
				Dec. 8.			Dec. 16.					
IV	64	[1] 1.24	Dec. 1	5	0	0	....	....	....	5 killed in 7 days.	100	Average temperature 55.9° F.; larvæ did no feeding.
V	64	8.34	...do.....	3	2	0	2	0	0	5 killed in 15 days.	100	Average temperature 55.2° F.; larvæ did no feeding.
VI	64	11.44	...do.....	2	3	0	3	0	0	...do.....	100	Average temperature 55.2° F.; larvæ did no feeding.
VII	.....	(1)	Check...	0	0	5	1	0	4	.....	.....	4 larvæ fed continuously.

[1] Normal soil.

NOTE.—Cages contained 1 ounce of paradichlorobenzene and 5 larvæ each. All larvæ were placed 6 inches below the crystals.

In January and February, 1922, experiments were conducted on soils in which different temperatures were maintained and to which different amounts of moisture were added at the beginning of the tests. The higher temperatures were maintained by keeping the cages indoors and the low temperatures by icing the cages in the insectary. The highest outdoor temperature recorded during the course of the experiment was 70° F. At a maximum temperature of 90° F. and a moisture content of from 7.6 to 27.6 per cent, all larvæ were killed in from 11 to 13 days. At a maximum temperature of 80° F. and a moisture content of from 7.6 to 30.3 per cent, all larvæ were killed in from 11 to 13 days. At a maximum temperature of 70° F. and a moisture content of 7.6 per cent (normal soil), 5 larvæ were killed in 11 days. At the same temperature and a moisture content of 19.8 per cent, 5 larvæ were killed in 17 days; and with moisture 27.6 per cent, 1 larva was killed in 17 days, and the remaining 4 in 21 days. At a maximum of 54° F. and 6.4 per cent moisture (normal soil), 5 larvæ were killed in 23 days. At the same temperature and a moisture content of 20.7 per cent, 5 larvæ were killed in 29 days. The larvæ in the untreated cage were all alive and feeding at the close of the experiment. Table 11 summarizes the results. This table shows that the lower the temperature and the higher the moisture content, the slower is the rate of evaporation of the paradichlorobenzene, and this naturally influences the effectiveness of the treatment. Fairly high temperatures,[3] however, such as occur in Georgia during the period of treatment for the borer, even though the soil has a high percentage of moisture, will kill the borers within a few weeks.

[3] Average maximum daily temperature for the six-week period following the applications on October 10, 1921, was 73° F.

TABLE 11.—*Effect of different maximum temperatures and different amounts of moisture in the soil on the time required to kill peach-borer larvæ, 1922.*

INDOOR CAGES.

Cage No.	Maximum temperature during exposure.	Per cent of moisture in soil when larvæ were exposed to gas.	Date larvæ were exposed to gas.	Condition of larvæ. Jan. 11. Dead.	Jan. 11. Stupefied.	Jan. 11. Active.	Jan. 15. Dead.	Jan. 15. Stupefied.	Jan. 15. Active.	Jan. 17. Dead.	Jan. 17. Stupefied.	Jan. 17. Active	Days required to kill larvæ.	Per cent killed.	Remarks.
	° *F.*	*Per cent.*													
I	90	[1] 7.6	Jan. 4	1	4	0	4	1	0	5	0	0	13 days....	100	Average temperature 80.9° F.; strong odor of gas 6 inches down on Jan. 5; larvæ did no feeding.
II	90	18.1	4	0	5	0	5	0	0	...	...	...	11 days....	100	Average temperature 80.3° F.; strong odor not noted until Jan. 9; larvæ fed before death.
III	90	27.6	4	0	5	0	5	0	0	...	...	...	11 days....	100	Average temperature 80.3° F.; strong odor not noted until Jan. 11; larvæ fed before death.
IV	80	[1] 7.6	4	1	4	0	4	1	0	5	0	0	13 days....	100	Average temperature 69.5° F.; strong odor Jan. 5; larvæ did no feeding before death.
V	80	21.1	4	1	4	0	5	0	0	...	...	...	11 days....	100	Average temperature 69.5° F.; strong odor Jan. 11; larvæ fed before death.
VI	80	30.3	4	1	4	0	5	0	0	...	...	...	11 days....	100	Average temperature 69.5° F.; strong odor Jan. 11; larvæ fed before death.
VII	Check	[1]	4	0	0	5	0	0	5	0	0	5	.....	0	Larvæ fed continually.

OUTDOOR CAGES.

				Jan. 11. Dead.	Jan. 11. Stupefied.	Jan. 11. Active.	Jan. 17. Dead.	Jan. 17. Stupefied.	Jan. 17. Active.	Jan. 23. Dead.	Jan. 23. Stupefied.	Jan. 23. Active			
VIII	70	[1] 7.60	Jan. 6	0	5	0	5	0	0	...	...	...	11 days....	100	Strong odor noted Jan. 11; larvæ did no feeding before death.
IX	70	19.8	6	0	0	5	1	4	0	5	0	0	17 days....	100	Strong odor noted Jan. 19; larvæ fed before death.
X	70	27.6	6	0	0	5	1	2	2	1	4	0	1 killed in 17 days.	20	100 per cent killed in 21 days; larvæ fed before death; strong odor Jan 19.
XI	Check	.....	.....	0	0	5	0	0	5	0	0	5	.....	.....	Larvæ fed continually.

ICED CAGES.

				Jan. 20. Dead.	Jan. 20. Stupefied.	Jan. 20. Active.	Jan. 28. Dead.	Jan. 28. Stupefied.	Jan. 28. Active.	Feb. 4. Dead.	Feb. 4. Stupefied.	Feb. 4. Active			
XII	54	[1] 6.4	Jan. 13	0	5	0	0	5	0	5	0	0	23 days....	100	Strong odor noted Jan. 28; larvæ fed before death.
XIII	54	20.7	13	0	0	5	0	4	1	0	5	0	None killed in 23 days.	0	100 per cent killed in 29 days; larvæ fed before death; odor of gas remained mild in this cage.
XIV	Check	.....	.....	0	0	5	0	0	5	0	0	5	.....	.....	Larvæ fed continually; made cases and entered bark furnished for food.

[1] Normal soil.

NOTE.—All cages contained 1 ounce of paradichlorobenzene and 5 larvæ each. All larvæ were placed 6 inches below the crystals.

SUMMARY.

Large doses of paradichlorobenzene, ranging from 1½ to 2½ ounces, to which the tree is exposed for 4, 8, or 12 days, are not as effective against the peach borer as three-fourths ounce or 1-ounce doses with an exposure of from 4 to 6 weeks.

The cambium layer of all peach trees ranging in age from 1 to 5 years treated with paradichlorobenzene for experimental purposes was uninjured in the summer following the application in the fall. Brown lesions were observed in the outer bark layers on a few trees, however, at a point near which the ring of crystals had been placed.

No injurious results from not tearing down the mounds within six weeks after making the application to peach trees in Georgia could be discerned.

During a normal fall in Georgia 1-ounce doses of paradichlorobenzene will entirely spend themselves, leaving little if any odor six weeks after the application.

In Georgia it is not necessary to uncover the base of the older trees four to six weeks after applying the chemical. It is advisable, however, to use this precaution against tree injury if the fall is abnormally cool, or if the material is applied late, or if it is used on young trees.

If the treatment is given to trees 4 years of age or younger, use three-fourths ounce doses. For trees 5 years of age and older use the 1-ounce dose.

Spring treatments of paradichlorobenzene in Georgia are not as effective against the peach borer as the early fall treatments. Spring applications gave a borer mortality of 72.4 per cent, compared with from 95 to 100 per cent mortality from using the material in middle October.

Very poor results were obtained in Georgia by applying the crystals during late November or early December. The most satisfactory results are obtained in central Georgia by applying the chemical October 10.

In the laboratory 91 to 135 days were required for the evaporation of one-half ounce doses of paradichlorobenzene imbedded from 4 to 6 inches below the soil surface. One-half ounce doses placed on the soil surface evaporated in 16 days. One would conclude from this laboratory experiment that the soil mounded on top of the crystals to prevent surface washing and to serve as a container for the gas should not be deep, as the deeper the crystals from the top of the soil the slower the gas will generate. Of course the normal rate of evaporation of paradichlorobenzene around peach trees in an orchard is much faster than it would be in the laboratory—the latter being at a lower temperature.

Laboratory tests show that the gas is liberated at about the same rate in both sandy loam and clay soils.

Laboratory experiments show that the gas will kill peach-borer larvæ as far down as 1 foot below the soil level, and under laboratory conditions the gas killed all larvæ at that depth within three weeks.

The lower the temperature and the higher the moisture content of the soil, the slower is the action of the gas on the borers.

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